CHROMOSOME RELATIONS IN THE SPERMATOCYTES OF ONISCUS.

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Recent work on the germ cells of animals has shown that the chromosomes contained within one nucleus frequently are not all of the same size. It has been known for some time that in insects and spiders one or more of the chromosomes, the so-called accessory, is smaller than the others and also differs in its behavior. With regard to chromosomes other than the accessory, Sutton,[1] in his studies on the spermatogenesis of *Brachystola* discovered a well-marked difference in size. Montgomery's [2] studies of the chromosomes of various Hemipteran species also revealed a variation in size of chromosomes occupying the same nucleus, and McClung,[3] in a recent paper on the spermatocytes of Orthoptera has described a remarkable structure, strikingly larger than the other chromosomes, which he has named "multiple chromosome," and which he interprets as being formed by the association of a number of chromosomes. The still more recent work of Morgan [4] and Stevens [5] on aphids indicates much the same thing. Morgan studied the eggs of Phylloxerans and shows in his figures of *Phylloxera caryæ-globuli* a distinct difference in the size of the chromosomes. Miss Stevens investigated a number of species of plant lice and concludes that each species is characterized by a definite number of chromosomes.

Chromosomes of the same nucleus may differ not only in size but also in shape. In a paper published in 1902 [6] I showed that

[1] W. S. Sutton, "On the Morphology of the Chromosome Group in *Brachystola magna*," BIOL. BULL., 4, No. 1, 1902.

[2] T. H. Montgomery, Jr., "A Study of the Germ Cells in Metazoa," *Trans. Am. Phil. Soc.*, 20, 1901.

[3] C. E. McClung, "The Chromosome Complex of Orthopteran Spermatocytes," BIOL. BULL., 9, No. 5, 1905.

[4] T. H. Morgan, "Male and Female Eggs of Phylloxerans of the Hickories," BIOL. BULL., 10, No. 5, 1906.

[5] N. M. Stevens, "Germ Cells of Aphids," Carnegie Inst., May, 1906.

[6] M. L. Nichols, "Spermatogenesis of *Oniscus asellus*, Linn.," *Proc. Am. Phil. Soc.*, 41, No. 168, 1902.

in the equatorial plate of the first maturation division of the male reproductive cells of the wood-louse, *Oniscus*, there occur chromosomes of three kinds. Some are straight or dumb-bell shaped, others are crescent shaped. In these two forms the component parts of the bivalent chromosomes lie end to end. A third form exists in which the univalent chromosomes are joined not end to end, but side by side. In each type a split may be observed running the length of the chromosomes and the first division is therefore reducing. In the prophase the third type is represented usually by rings, occasionally by V-shaped structures (Figs. 7 and 14), while the crescents appear as curved rods and the remainder as straight or dumb-bell shaped rods. The reduced number of chromosomes, as far as could be determined, is sixteen. Of this number two have the ring form, two are crescents and the others are straight or dumb-bell shaped. The chromosomes vary somewhat in size, but in *Oniscus* the differences are not so great as in some of the insects before mentioned. The largest have the ring form, the smallest are straight (Figs. 1, 2, 4, 17, 18). Sometimes one of the two rings is complete or nearly so, the other incomplete (Figs. 1, 11). The rings lie on opposite sides of the nucleus, sometimes directly opposite, in other cases apparently shifted to one side or the other (Figs. 1, 2, 3, 8, 9, 11, 15, 16). Since they are the largest and most easily recognized of the nuclear elements they form convenient points of localization.

The crescent form is the next most easily recognizable. Of this type there are likewise two, one of them sometimes more strongly curved than the other. They also occupy opposite sides of the nucleus and at points between the positions occupied by the rings (Figs. 3, 4, 8, 9, 10, 11, 15, 16, 19).

The relative position of the rings and crescents is more readily determined than that of the rods, because they are not so numerous and are also distinguished by their shape. Repeatedly however I have observed an arrangement of three or four straight chromosomes in a row (Figs. 9, 12, 17). One of the smaller of the straight chromosomes, too, is often seen lying not far from one of the crescents (Figs. 8, 13, 17, 18).

These facts point to an individuality of the chromosomes and also indicate a tendency to localization in the nucleus. The evi-

dence for this is further strengthened by the manner in which the chromosomes develop from the resting nucleus. The resting nucleus is a network formed by the gradual lengthening and anastomosis of threads which retain their individuality until just before the formation of the nuclear membrane. From it arise the chromosomes of the first maturation division by a breaking apart of the threads of this network and their gradual shortening and thickening.

The question presents itself whether these relations of form and position of the chromosomes are peculiar to *Oniscus* or characteristic of the land isopods as a group. Two other genera I have examined, *Porcellio* and *Armadillo*. The spermatogenesis of these is similar to that of *Oniscus*, but the cells are smaller, in *Armadillo* so small as to make an examination of the chromosomes very difficult and uncertain.

The cells of *Porcellio* more nearly approach those of *Oniscus* in size and I was able to compare the prophase of the first division in the two animals. Although the chromosomes of *Porcellio* are smaller than those of *Oniscus*, the peculiarities of shape and arrangement are similar. In *Porcellio* also are present two rings lying opposite each other with a crescent between. More than one crescent in a nucleus, however, I have not seen. One at least of the straight chromosomes appears considerably smaller than the others and, as in *Oniscus*, frequently lies not far from the crescent (Figs. 5 and 6). I was not able to determine the number of chromosomes in *Porcellio*, as my preparations contained no spermatocytic mitoses. Besides the smaller size of the chromosomes would make an accurate determination even more difficult than in *Oniscus*. As far as can be judged from the appearance of the prophase, the number would seem not to be very different in the two genera.

The presence of chromosomes of the three forms described within the same germ nucleus is not then peculiar to *Oniscus*, but probably is characteristic of the group, the genera being visibly distinguished from each other by differences in size of the chromosomes and possibly by slight differences in the shape of homologous chromosomes.

Comparing the results obtained for various animals and plants,

it seems safe to conclude that any correlation existing between the shape of the chromosomes and the tangible bodily characteristics is not very close nor exact. Species quite distinct from each other may possess chromosomes of almost the same shape and size. Especially is this true of plant species. On the other hand, species closely resembling each other may have chromosomes of perceptibly different shape or size. This is even more obviously the case with the number of chromosomes. In some instances a difference in number may be accompanied by difference in sex,[1] in others by specific differences.[2] Again the same number may characterize groups as widely different as angiosperms, mammals and insects[3]; while related species of the same genus may differ in number.

Nevertheless in a general way there appears to be some correspondence between the bodily attributes of a group and the character and behavior of the chromosomes of that group. Chromosomes of a particular shape are more characteristic of certain groups than of others. Thus, the form in which the limbs of the bivalent chromosomes are twined about each other is frequently found in flowering plants and also in amphibia, the ring form is particularly apt to occur in arthropoda and a shape somewhat like a shepherd's crook, with a slender body and thickened, curved extremity, is often seen in mollusks and worms. Again the peculiar chromosome known as the accessory so far has not been found outside of the Tracheata.

No doubt the shape, possibly also the number of chromosomes, is determined by complex physical and chemical conditions which may not have any direct relation to visible bodily characters and two chromosomes of the same shape and size may contain potentialities of quite different nature, just as an apple and its waxen imitation, although of the same size and shape, have very diverse properties.

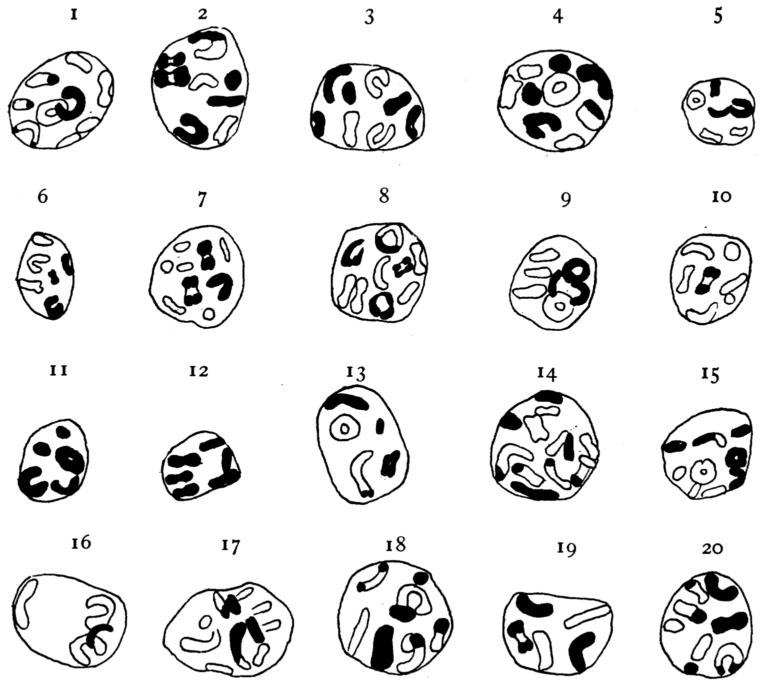
A parallel condition may be seen in the relation of the shape and size of the egg to the bodily characters of the organism developing from it. Forms differing as widely as fish and

[1] E. B. Wilson, "The Sexual Differences of the Chromosome Groups in Hemiptera," *Jour. Exp. Zool.*, III., No. 1, 1906.

[2] Montgomery, Morgan, Stevens, *loc. cit.*

[3] E. B. Wilson, "The Cell in Development and Inheritance," p. 206, 1900.

echinoderms may have eggs of about the same size and shape, but of varying potentialities. Yet here, too, there are peculiarities of constitution and behavior characteristic of certain groups rather than of others. There may be as good ground for determining the relationship of organisms by the behavior of chromosomes as by the character of cleavage in the egg, but in the former case the handicap is severe because of the minute size of the elements and the fact that changes of important nature may take place in the constitution of the chromosome without producing any effect tangible for modern microscopic methods. If, however, specific or other differences happen to coincide with visible variations in the chromosomes, such objects form convenient points of departure for the study of such problems as the determination of sex and the relation of paternal and maternal chromosomes in the cells of hybrid offspring.



Explanation of Figures.

With the exception of 5 and 6, the figures are prophases of the first maturation division of *Oniscus asellus* Linn. Nos. 5 and 6 are from *Porcellio*. The drawings were made with the camera lucida, Zeiss oc. 6, obj. $\frac{1}{12}$ imm. at the level of the table.